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An Analysis of Application of Mean Glandular Dose and Factors on Which It Depends to Patients of Various Age Groups

Suad Kunosic^{1,2}

¹*Department of Physics, Faculty of Natural Sciences and Mathematics, University of Tuzla*

²*Department of Biophysics, Medical Faculty, University of Tuzla
Bosnia and Herzegovina*

1. Introduction

Breast cancer is the most frequently diagnosed type of cancer nowadays and it is the leading cause of death caused by cancer in women (Jemal et al., 2011). It has become one of the main health problems both in developed and in developing countries. More than a million new cases of breast cancer are diagnosed every year all over the world (Ferlay et al., 2004). According to researches of the American Cancer Society (American Cancer Society, 2002), since 2002 breast cancer has been the second largest cause of death caused by cancer in women. According to a research conducted in 2007 in Korea, breast cancer was the second most frequently detected type of cancer in women (Kyu-Won et al., 2010). In 2008 there were 3, 2 million (Ferlay et al., 2010) new cases of cancer in Europe out of which 421, 000 (13,1%) (Ferlay et al., 2010) cases were breast cancers. According to the mentioned research, after colorectal cancer (436, 000 cases) breast cancer is the second most frequently registered cancer in Europe (Ferlay et al., 2010). In Bosnia and Herzegovina 1600 new cases of breast cancer are registered every year (Saric, 2009). Nowadays, mammography represents the best diagnostic way for detection of breast cancer. This diagnostic medical discipline applies a specially designed roentgen apparatus for breast examination. A good topographic position and a high degree of mobility of the breast (Fajdic, 2001) enable a great number of early diagnosed breast cancers detected with mammography. Ultrasound breast diagnostic is often used as an additional method to classic mammography for breast cancer detection, especially identification of cysts in the breast (Fajdic, 2001). Nowadays there are classic (film-screen) and digital mammography. While digital mammography enables a superior contrast resolution, its spatial resolution is somewhat lower in regard to the standard technique (Kuzmiak et al., 2005). Advantages and disadvantages of these two types of mammography were compared in more than ten studies (Rosselli Del Turco et al., 2007; Skaane, 2009). One of the main arguments for giving priority to digital mammography in regard to classic mammography was the fact that digital systems cause less radiation during an examination (Hermann et al., 2002; Moran et al., 2005). The newest study shows that digital mammography cannot guarantee significantly lower patient doses in regard to classic mammography (Hauge et al., 2011). The objective of most studies about mammography is to define benefits and risks caused by application of radiation in

mammography. The size which best describes amount of risk for glandular tissue caused by application of radiation in mammography is called mean glandular dose (MGD). There are two critical age groups of patients in mammography: patients 40 to 49 years of age and patients 50 to 64 years of age. Naturally, patient doses have to be defined for all other patients who undergo mammographic diagnostic but do not belong to the mentioned age groups. Advantages of a routine mammography in timely diagnosing of breast diseases are great. Mammographic screening reduces mortality caused by breast cancer for women 39 to 69 years of age (Heidi D. Nelson et al., 2009). This study aims to define patient doses and factors which influence them for all critical groups of patients in routine mammography. Since a mammographic examination of each breast consists of mediolateral and craniocaudal projection, it was necessary to define patient doses for individual projections and for the complete mammographic examination.

2. Materials and methods

2.1 A procedure for measuring of measurable parameters in mammography

Like any other study in diagnostic radiology, this one also aimed to first collect all measurable parameters during a routine mammography. It was necessary to collect not only physical but also technical, diagnostic and medical parameters.

During mammographic diagnostic, it is necessary to note physical and technical parameters, and after completion of mammography also diagnostic and medical parameters which can be offered by a radiologist. On a basis of collected data about a patient (age, mass, height) and with an established body mass index (BMI), one can examine its relation with patient doses in mammography (Schubauer-Berigan et al., 2002; Jamal et al., 2003) and a frequency of patient's going for a regular mammographic examination (Zhu et al., 2006). All experimental measuring of doses during diagnostic mammographic examinations was performed at the Department of Mammography of Public Health Institution Health Center Tuzla. For diagnostic examinations of patients we used a GE Healthcare Alpha ST (Mo/Mo) mammographic apparatus. In classic mammography (film-screen), Mo/Mo dominates as one of the most frequently used meta/filter combinations (Hauge et al., 2011), and many mammographic systems, such as Alpha ST, have a Mo/Mo meta/filter combination as their only choice. The measuring was done in the period from May 2008 to January 2011 and it involved 329 female patients between 40 and 64 years of age.

The following data were recorded during a diagnostic examination:

- a. patient's age,
- b. applied clinical spectrum (meta/filter combination),
- c. CBT (compressed breast thickness) and type of projection (CC, MLO) for each breast,
- d. exposition factors: charge I-t (mAs) and voltage (kVp),
- e. size of applied film (18 x 24 or 24 x 32),
- f. number of previous mammographic examinations underwent by every patient,
- g. type of diagnostic examination: routine control examination, post-operative control examination; an enlarged additional image of a certain projection is necessary; a repeated image because of insufficient sharpness.
- h. possible ultrasound control.

The mentioned data were used for calculation of strength of kerma in the air, filter half-values and conversion factors for age groups. Mean glandular dose (MGD) for the breast was defined according to these parameters. MGD doses were defined for every individual projection and for the complete mammographic examination. A statistical dependency (correlation) between compressed breast thickness and MGD dose was defined for every age group and for mediolateral and craniocaudal projection of every age group.

A correlation between ultrasound and mammographic breast examination was found and it was confirmed that these two diagnostic disciplines complement each other excellently in early breast cancer prevention (Harlow et al., 1999; Kuhl et al., 2005). A combination of mammography and ultrasound with a possible ultrasound cytological puncture offers a basis for a reliable diagnosis of the smallest malignant formations in breasts (Mainiero, 2010). A number of underwent mammographic examinations in a correlation with patient's age gave an answer to many questions, such as: a level of information about breast cancer available to patients, need for a routine mammography in breast cancer prevention, importance of self-examination for women and differences in psychological behavior of patients during the first and after several mammographic examinations. A type of diagnostic examination on a mammography unit and a way of its performance showed the importance of a role of a radiology technician and his/her direct communication with a patient during the process for obtaining a good quality of image in mammographic diagnostics.

2.2 Quality control

Quality control (Geise et al., 1988; Hendrick et al., 2002) in mammography contains a set of tests (Perry et al., 2006) which can be divided according to priority and a level of training of personnel who perform them. Some tests require usage of special equipment or special work conditions. That is why sometimes in some institutions there is a possibility of failure to implement a complete quality control of a mammography system. Regular quality controls of mammography units in some countries contributed to decreasing of patient doses and improvement of quality of mammographic images (Maccia et al., 1995; Zdesar, 2000; Vassileva et al., 2005; Ciraj-Bjelac et al., 2011) and improvement of functioning of a mammography unit (Zoetelief et al., 1992). The tests can be grouped in the following way:

- Tests for mammographic device,
- Tests for films, foil and processor,
- Tests for quality of images,
- Calculation of breast dose

Quality control in mammography was regularly performed during a three-year period of data collection and its long-term strategy was to support reduction of mortality rate caused by breast cancer. A special attention was dedicated to tests for mammographic devices. Anode voltage value, dose reproducibility and filter half-value (HVL) without returnable radiation were measured for different settings of kVp and meta filter combination (a controlled mammography unit had only one meta filter combination Mo/Mo) following recommendations of the quality control protocol (Perry et al., 2006), which defines measuring methodology and frequency. When measuring half filter value (HVL) one used aluminium filters of extremely high purity (99,9%). First, measuring was done several times

without a filter in order to obtain an initial exposition value. Afterwards, sets of aluminium filters of various thicknesses were settled between the focus and detectors. Roentgen tube voltage ranged from 22 to 32 kVp and every voltage value was measured several times in order to obtain half the dose in regard to the initial dose value on the detector. Possible HVL values in mammography range from 0,25 to 0,45 mmAl. All tests for mammographic device were done with Barracuda instrument.

2.3 Dosimetry

For every mammogram MGD was defined on a basis of conversion factors calculated by Dance et. al. (Dance et al., 2000) and a calculated K (entering air kerma measured freely in air without backscatter), using the following relation:

$$MGD = K g c s$$

For every individual exposition K was calculated from post – exposure mAs ($I \cdot t$) and output data for the x – ray set in $\mu\text{Gy mAs}^{-1}$ used in an exposition field. Conversion factors were calculated by Dance for a different clinical spectrum (target/filter combination), HVL, compressed breast thickness and breast glandularity. G and c are conversion factors to account for both X-ray beam characteristics and breast composition i.e., various percentages of fat and glandular tissue. Factor s includes a correction for applied type of the clinical spectrum and all screens were made using the same clinical spectra Mo/Mo.

2.4 Statistical analysis

The data were statistically processed in SPSS 17.0 and they were shown as standard deviation and confidence interval. Pearson's coefficient was used for statistical significance of correlation between MGD and CBT. A value of $p < 0.05$ was considered as indicative of significance.

3. Results and discussion

3.1 Age and compressed breast thickness

Age of examined patients varied from 40 to 64. The average age of the first group (40 – 49) was 45, 27 years (SD: 2,76) and of the second age group (50 – 64) it was 55,90 years (SD: 4,20). The average age of all of the patients was 51,63 (SD: 6,39). Distribution of compressed breast thickness in mammography was symmetrical to patient's age and it varied from 20 to 100 mm. Errors in defining compressed breast thickness varied in the range of ± 1 mm. There was a good correlation between patient's age and compressed breast thickness. A similar symmetry was noted in other works (Beckett & Kotre, 2000; Kunosic et al., 2010; Kunosic et al., 2011). Mean value of compressed breast thickness of the complete sample was 42,24 mm (SD : 14,86). It is known that compressed breast thickness value shows a certain tendency of growth in younger patients and a tendency of decline in older patients (Law et al., 1994), which proved as true in our examined sample. Mean value of compressed breast thickness in mediolateral projection was 20 to 23 % higher than in craniocaudal projection. This information is very important for understanding of results and explanation of obtained glandular doses for the breast from Tables 4. and 5.

3.2 Quality control

Accuracy of measured voltage in roentgen tube (maximum deviation) was $\pm 0,89$ kVp for voltage ranging from 22 to 32 kVp. Outgoing radiation (mGy/mAs) was measured several times during this study and it was within the range of ± 4 % from the initial value. The most frequently used voltage during performance of diagnostic examinations was 25 kVp (45,08 %). This voltage was applied in cases when compressed breast thickness varied from 20 to 28 mm, and sometimes with higher values of compressed breast thickness depending on age group to which a patient belongs.

Voltage of 26 kVp (19,18 %) was applied in most cases when compressed breast thickness was 28 to 34 mm while voltage of 27 kVp (13,69 %) was mainly applied when compressed breast thickness varied from 35 to 45 mm. Percentage of utilization voltage of 25, 26 and 27 kVp leads us to a conclusion that the greatest number of patients who underwent a routine mammography in this study had compressed breast thickness from 20 to 45 mm, if we assess utilization voltage. A significant percent of utilization was ascribed to voltage of 28 kVp (10,57 %) and 29 kVp (8,03 %) when compresses breast thickness varied from 40 to 53 mm and 54 to 63 mm, respectively. Voltage of 30 kVp (1,97 %) and 31 kVp (0,82 %) was applied for compressed breast thickness from 64 to 80 mm to make a compromise between mentioned values and obtain an image of better quality. Voltage of 32 (0,49 %) and 33 (0,16 %) kVp was used for extremely great values of compressed breast thickness from 81 to 100 mm.

Age group (years)	Number of images	Voltage								
		25	26	27	28	29	30	31	32	33
		(kVp)	(kVp)	(kVp)	(kVp)	(kVp)	(kVp)	(kVp)	(kVp)	(kVp)
	493	200	99	93	66	35	0	0	0	0
40 - 49										
	(%)	40,57	20,08	18,86	13,39	7,10	0,00	0,00	0,00	0,00
	727	350	135	74	63	63	24	10	6	2
50 - 64										
	(%)	48,14	18,57	10,18	8,67	8,67	3,30	1,38	0,83	0,28
	1220	550	234	167	129	98	24	10	6	2
Total										
	(%)	45,08	19,18	13,69	10,57	8,03	1,97	0,82	0,49	0,16

Table 1. Statistical illustration of applied voltage per age groups for complete sample during mammographic diagnostics.

When we analyze percentage of representation of voltage applied during diagnostic examinations per age groups we draw similar conclusions like for the complete sample, with a slight deviation. What is interesting to note here is that voltage of 30 – 33 kVp was not applied for the age group 40 – 49. Voltage of 25 kVp was mostly applied for this group while the difference in application of voltage of 26 and 27 kVp was insignificant. These three voltages were applied for about 80 % diagnostic examinations (Table 1.) of this age group. It is important to note that absence of application of extremely high voltage was compensated

with significant application of voltage of 28 and 29 kVp, which representation is greater in this age group in regard to the other age group (Table 1.).

A tendency of application of voltage of 25 kVp and voltage of 26 kVp was retained in the age group 50 to 64 years of age (Table 1). The difference in regard to the age group 40 – 49 reflects in significantly less application of voltage of 27 and 28 kVp (Table 1.) and greater utilization of voltage ranging from 30 to 33 kVp. This wide spectrum of voltage applied in the age group 50 – 64 was caused by a wide spectrum of compressed breast thickness.

3.3 X – ray technique

The greatest number of images taken during mammographic diagnostic was two for MLO and two for CC projection. The total number of images used for a complete diagnostic examination was 4. The same clinical spectrum (meta/filter) Mo/Mo was applied for all diagnostic examinations. 1220 images were taken to examine 329 patients (Table 2.), out of which 1172 images were taken for the complete mammographic examination of 293 (89,06 %) patients (two images for each projection). In this way both breasts were completely diagnostically processed (Hackshaw et al., 2000). 24 images were used for a routine control examination of one breast after a surgery or additional controls because of a certain doubt (one for each projection) to examine 12 (3,65 %) patients.

Remaining 24 (7,29 %) patients were examined with application of 24 images mainly because of a need for an improved image (of better quality) for some of projections.

Age group (years)	Number of patients	Number of images taken per a patient during mammography			Type of film applied per a patient	
		4 images	2 images	1 images	18 x 24	24 x 32
	132	119	4	9	71	61
40 - 49	(%)	90,15	3,03	6,82	53,79	46,21
	197	174	8	15	97	100
50 - 64	(%)	88,32	4,06	7,61	49,24	50,76
	329	293	12	24	168	161
Total	(%)	89,06	3,65	7,29	51,06	48,94

Table 2. Statistical illustration of number of images taken and types of films applied for all age groups and complete sample during mammographic diagnostic.

Percentage of patients for whom taking two images was necessary for examination of one breast was 3,65 %, and it indicates a need for a routine mammographic control because it represents a percentage of patients in whom a timely routine control detected breast cancer. It is in common in all of developed countries of the world which have a developed program for early breast cancer detection to examine all patients with application of 4 images (two images for each projection) with a desire to obtain a complete clinical picture (Nelson et al., 2002; Miller, 2005).

Such approach is a result of routine mammography which is compulsory every third year in developed countries. As a result, there is a great number of patients with early detected breast cancer (Greenlee et al., 2000), which automatically influences a decrease of mortality caused by breast cancer (Tabar et al., 2003; Gøtzsche & Nielsen, 2006; Gøtzsche, 2011; D'Orsi & Newell, 2011).

Age group (years)	Number of images	Mammographic image			Mammographic image		
		18 x 24 (cassette)			24 x 32 (cassette)		
		4 images	2 images	1 image	4 images	2 images	1 image
	493	63	3	5	56	1	4
40 - 49	(%)	88,73	4,23	7,04	91,80	1,64	6,56
	727	88	4	5	86	4	10
50 - 64	(%)	90,72	4,12	5,15	86,00	4,00	10,00
	1220	151	7	10	142	5	14
Total	(%)	89,88	4,17	5,95	88,20	3,11	8,70

Table 3. Statistical illustration of number of images taken depending on size of film applied for all age groups.

An analysis of applied mammographic images per age categories (Table 3.) revealed new interesting information. Over 90% of complete mammographic examinations were performed in the first age group where belong younger patients (40 to 49 years of age). As expected, number of 18 x 24 images is greater because this is the population where the breast (Kopans et al., 2003), as a very dynamic organ, passes through a set of dynamic changes during its growth and development. Mammographic images 24 x 32 are mainly used for patients between 46 and 49. A percentage of control examinations after a surgery of one breast is small, not greater than 3,1 %. It is expected for this age category to have a lot of blur and unclearness in mammographic images, which sometimes cause repetition of one of diagnostic projections (1 image, CC or MLO). Percentage of repeated images is a bit smaller than 7 % (Table 3.), which is quite satisfactory for such huge population and adequate for a radiologist to obtain a clear clinical picture and to define a final diagnosis on a basis of an additional image. A complete mammographic examination was conducted in 44, 67 cases from the second age group (50 - 64) with 18 x 24 film and in 43,65 % cases with 24 x 32 films. With this population, there is a tendency of increasing of a number of control examinations for 50% in regard to the younger age group. This is a confirmation of the tendency of growth of early breast cancer detection in women who frequently undergo routine controls and self-examinations. Percentage trend of 7,62 % of repeated images in one projection is retained, although a number of diagnostically treated patients increased for 33% in regard to the previous group. A slight advantage for the benefit of usage of smaller 18 x 24 images in regard to bigger 24 x 32 images in a complete diagnostic examination corresponds to the average compressed breast thickness of diagnostically processed population (Table 5.). The mentioned data leads us to the conclusion that the average compressed breast thickness of the examined population with such great sample must be less than 50 mm, in comparison with other study (Kunosic et al., 2010).

3.4 Patient’s doses

The most frequently used procedure in a routine mammography includes 2 images of every breast, craniocaudal and mediolateral. Even if there is a visible anomaly at one breast, it is necessary to perform a diagnostic mammographic examination of both breasts. Such procedure enables us to compare both breasts and to detect possible anomalies into details (Hackshaw et al., 2000). In the last 20 years a set of studies has been conducted in Europe with the objective to define MGD (Wall & Roberts, 1992; Faulkner et al., 1995; Klein et al., 1997; Beckett & Kotre, 2000; Adlien et al., 2005; Assiamah et al., 2005; Tsapaki et al., 2008; Kunosic et al., 2010; Ciraj-Bijelac et al., 2010). Similar researches were conducted on Thailand (Sookpeng & Ketted, 2006), in Iran (Bouzarjomehri et al., 2006), in the USA(Gentry & De Werd, 1996), Malaysia (Jamal et al., 2003), Australia (Heggie, 1996), Korea (Oh et al., 2003) and many other countries all over the world. Table 10.4. illustrates results regarding MGD for every individual projection and for the complete diagnostic examination of all patients during MLO and CC diagnostic examinations.

	Number of images	Voltage	CBT (mm)	It (mAs)	MGD (mGy)	
		kVp ± SD	Mean ± SD	Mean ± SD	MGD ± CI	Third quartile
Total	1220	26,31 ± 1,56	42,24 ± 14,86	40,71 ± 12,73	0,90 ± 0,01	0,99
CC	613	25,75 ± 1,09	36,88 ± 11,95	35,88 ± 10,27	0,83 ± 0,01	0,91
MLO	607	26,87 ± 1,75	47,76 ± 15,54	45,58 ± 13,12	0,96 ± 0,02	1,09

Table 4. Complete statistical illustration of voltage, compressed breast thickness, MGD for all patients and two different projections (CC, MLO). (MLO - Mediolateral oblique view; CC - Craniocaudal view; SD - Standard deviation, CI - Confidence interval for the mean of 95 %; CBT - Compressed breast thickness)

Values of MGD and compressed breast thickness (CBT) were defined for a sample of 1220 images (613 CC and 607 MLO projections). Mean value of a patient dose for the complete CC projection was 1,66 mGy and for MLO projection 1,92 mGy. A significant difference (Table 4.) between the mentioned doses (according to calculated values) was caused by compressed breast thickness and it was 13,54 %. Similar results were noted in works of other authors (Gentry & De Werd, 1996; Heggie, 1996; Young, 2000; Jamal et al., 2003; Oh et al., 2003; Bouzarjomehri et al., 2006; Sookpeng & Ketted, 2006; Tsapaki et al., 2008; Kunosic et al., 2010). A sample of a significant increase of doses in MLO in regard to CC projection can be explained with the fact that pectoral muscle (Helvie et al., 1994; Young, 2000) is involved in MLO projection which causes an increase of thickness of compressed tissue and requires greater exposition for an image of a better quality. The total dose for a complete mammographic examination was 3,58 mGy, which is much less than 4 mGy which is the ceiling for mammography. In comparison with other studies (based on a principle of a great sample) the obtained patient dose is less in regard to a study conducted in Sweden (Eklund et al., 1993) which involved a sample of 1350 patients and in regard to a study conducted on 490 patients in Australia (Heggie, 1996), and it correlates well with results of studies from Korea (Oh et al., 2003) and Greece (Tsapaki et al., 2008). A study conducted in Iran included 246 patients (Bouzarjomehri et al., 2006) and showed that an obtained MGD dose for a

complete mammographic examination in that country was 5,57 mGy, which is significantly more in regard to this study and which, most probably, is a consequence of a quality control system which was established late and differences in compressed breast thickness. The mentioned studies did not use conversion factors according to Dance (which are used in this study), but in Austria, Korea and Malaysia one used conversion factors according to Wu (Wu et al., 1991), in Sweden according to Rosenstein and in Iran according to Sobol (Sobol & Wu, 1997). Values of MGD dose for a complete mammographic examination in Bosnia and Herzegovina are 5,0 % higher in regard to results obtained from 300 patients in Malaysia (Jamal et al., 2003) and 7,8 % higher in regard to the most complete study (Young & Burch, 2000) conducted in the Great Britain which included 8745 patients. More than 70 % of all of mammographic diagnostic examinations was done with doses less than 3,2 mGy. According to a correlation analysis (Picture 10.2.), there was a considerable significance (Fig. 1.) between MGD and CBT ($r = 0,689$, $p < 0,01$).

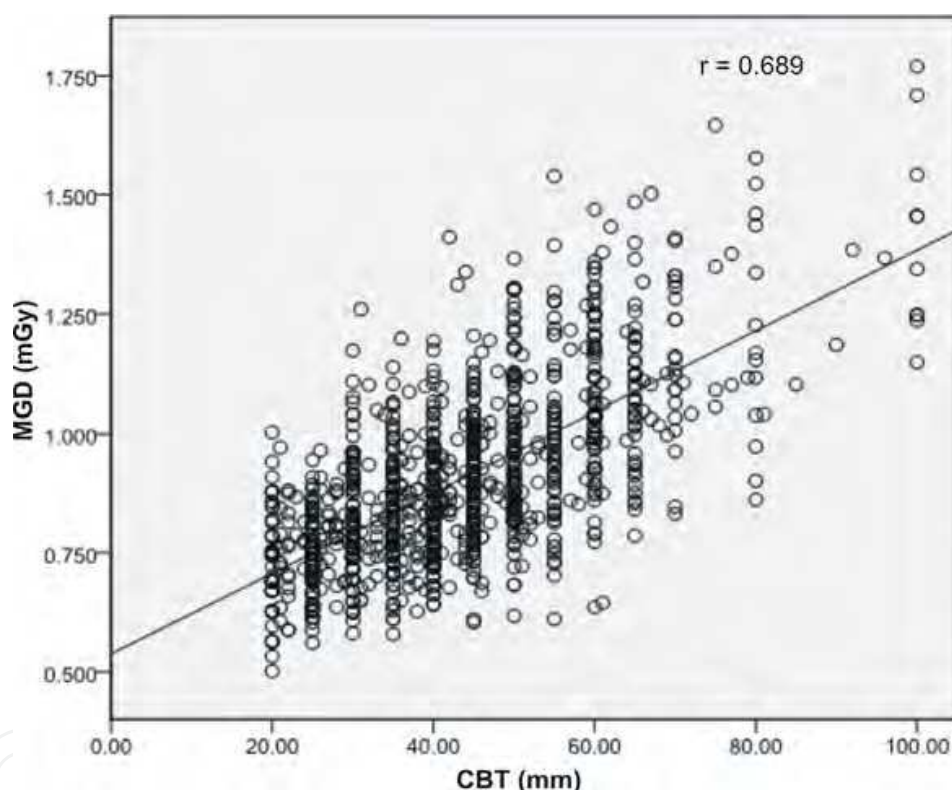


Fig. 1. Correlation between MGD and CBT.

A similar positive correlation between MGD and CBT was noted on a much smaller sample of Bosnian patients (Kunosic et al., 2010). An influence of CBT on patient doses during mammographic diagnostic examinations was confirmed by other authors in their researches (Wall & Roberts, 1992; Gentry & De Werd, 1996; Dance et al, 2000; Kruger et al, 2001; Oh et al., 2003; Bouzarjomehri et al., 2006; Sookpeng & Kettled, 2006; Bor et al, 2008; Robinson & Kotre, 2008) and some authors used this dependency to predict patient doses through training of artificial neural networks (Ceke et al., 2009). The number of previously conducted mammographic examinations for the complete group was 1,80 (SD: 0,66) while more than 75 % of patients underwent at least 2 mammographic examinations in their lives. All patients underwent an ultrasound breast examination.

3.5 Patient's doses for two different age groups

It is extremely important to examine a relation between projections (craniocaudal and mediolateral projection) during a mammographic diagnostic, compressed breast thickness and mean glandular dose received by a patient during one exposition and during the complete examination for two different age groups (Wall & Roberts, 1992; Gentry & De Werd, 1996; Heggie, 1996; Klein et al., 1997; Young, 2000; Young & Burch, 2000; Oh et al., 2003; Jamal et al., 2003; Sookpeng & Kettled, 2006; Bouzarjomehri et al., 2006; Tsapaki et al., 2008; Ciraj-Bijelac et al., 2010; Kunosic et al., 2010). Patients are divided into a group of younger patients (40 - 49) and a group of older patients (50 - 64), according to the European Protocol for Dosimetry in Mammography (Perry, et al., 2006). Table 5. illustrates results regarding MGD doses for every individual projection (MLO and CC) and for the complete mammographic examination of the mentioned projections. The first age group (40 - 49) consisted of 132 patients for whose examination 493 mammographic images were taken. Mean value of compressed breast thickness was 41,15 mm (SD: 15,06).

Age group (years)		Number of images	Voltage	CBT (mm)	It (mAs)	MGD per exposure(mGy)	
			kVp ± SD	Mean ± SD	Mean ± SD	MGDs ± CI	Third quartile
	Total	493	26,26 ± 1,30	41,15 ± 15,06	40,46 ± 12,87	0,88 ± 0,01	0,96
40 - 49	CC	246	25,76 ± 0,99	36,18 ± 12,53	35,72 ± 10,81	0,82 ± 0,01	0,88
	MLO	247	26,74 ± 1,38	46,11 ± 15,74	45,18 ± 13,05	0,94 ± 0,02	1,05
	Total	727	26,34 ± 1,72	42,98 ± 14,69	40,87 ± 12,64	0,90 ± 0,01	1,00
50 - 64	CC	367	25,74 ± 1,16	37,35 ± 11,54	35,98 ± 9,90	0,83 ± 0,01	0,91
	MLO	360	26,95 ± 1,96	48,73 ± 15,34	45,86 ± 13,18	0,98 ± 0,02	1,12

Table 5. Complete statistical illustration for voltage, compressed breast thickness, MGD for three different age groups and two different projections (CC, MLO). (MLO - Mediolateral oblique view; CC - Craniocaudal view; SD - Standard deviation, CI - Confidence interval for the mean of 95 %; CBT - Compressed breast thickness).

A slight tendency of increasing of compressed breast thickness with aging was noted with this age group (Klein et al., 1997; Moore et al., 2005). Compressed breast thickness in MLO projection was 21,53 % higher than the one noted in CC projection. Doses in MLO and CC projection were 1,88 mGy and 1,64 mGy, respectively. The mentioned values of doses are within the frame of results promoted by K.C.Young (Young, 2000) for the age group 40 to 48. A considerable significance was noted between MGD and CBT (Fig. 2.) with this age group (r = 0,689 ; p < 0,01). More than 75 % of doses for individual (one) image in CC projection was less than 0,88 mGy while more than 75% of individual images in MLO projection was below 1,05 mGy. Doses received in an individual MLO projection were for about 12,76 % higher than in CC projection, which is mostly contributed by a difference in compressed breast thickness in the mentioned projections. The number of performed mammographic examinations for this age group as of now is 1,68 (SD: 0,60) while more than 75 % of patients underwent at least 2 mammographic examinations in their lives, which is a good average considering the fact that this is the youngest group and bearing in mind a very bad economic status of the country.

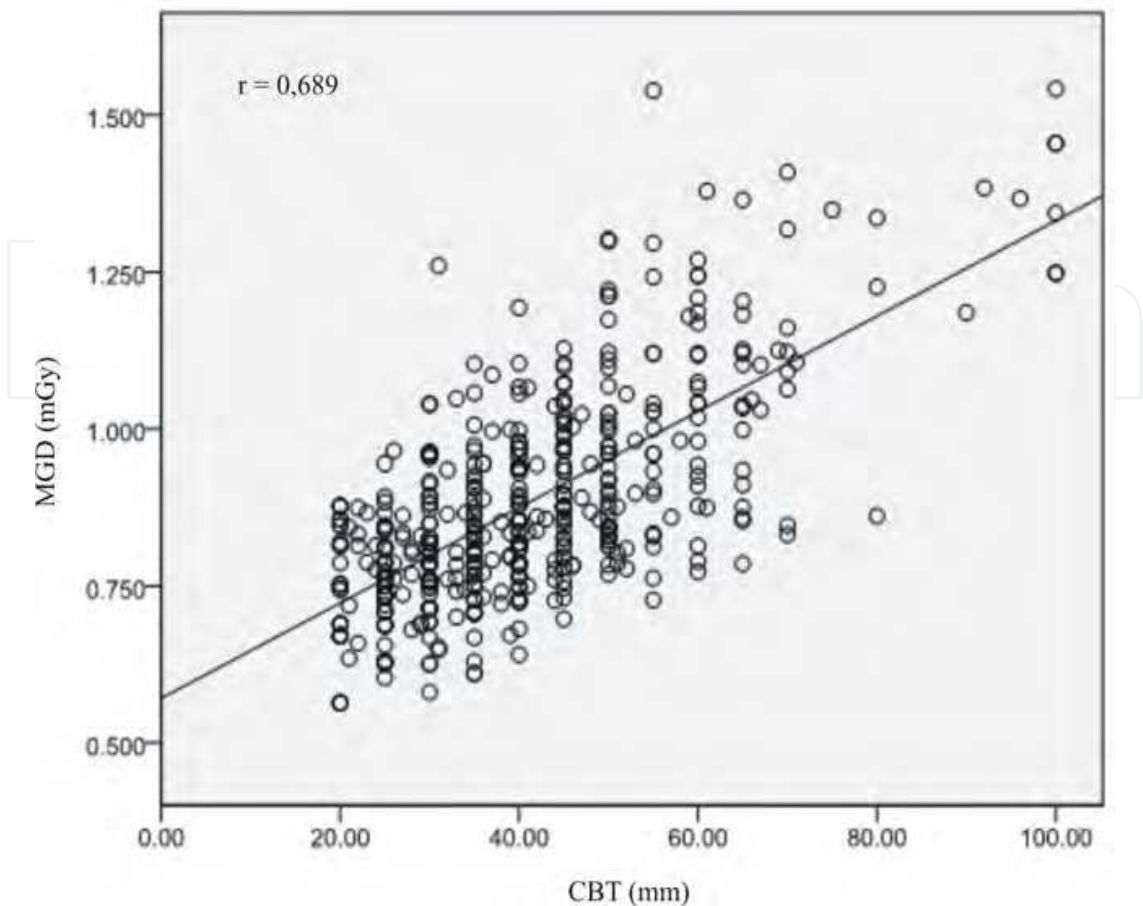


Fig. 2. Correlation between MGD and CBT for age group 40 – 49.

The second age group, 50 – 64 years of age, involved 197 patients for whose mammographic examination one made 727 images (Table 10.9.). Mean compressed breast thickness was 42,98 mm (SD: 14,69). Compressed breast thickness in MLO projection was 23,35 % higher than in CC projection. Patient doses for the complete MLO and CC image were 1,96 mGy and 1,66 mGy, respectively. These results comply well with results from the work of Burch and Goodman (Burch & Goodman, 1998). A patient dose in CC projection is something higher in regard to a study conducted in the USA (Gentry & De Werd, 1996) where one measured mean compressed breast thickness of 4,5 cm and MGD of 1,5 mGy for the mentioned projection. What is interesting is that values of doses decreased with an increase of patients' age in this group (Beckett & Kotre, 2000; Bouzarjomehri et al., 2006), probably because of a change (decrease) of breast glandularity (Eklund et al., 1993; Heggie, 1996). More than 75 % of doses for an individual (one) image in CC projection was less than 0,91 mGy while more than 75% of individual images in MLO projection was below 1,12 mGy. Doses received during an individual MLO projection were for 15,31 % higher than in CC projection, which is mostly contributed by a difference in compressed breast thickness in the mentioned projections. A correlation analysis of this age group showed a considerable significance between MGD and CBT ($r = 0,692$; $p < 0,01$). The number of performed mammographic examinations for this age group as of now is 1,88 (SD: 0,69) and more than 75 % of patients underwent less than 2 mammographic examinations in their lives. This information is discouraging since the number of examinations performed as of now in comparison with the number in developed countries should be much greater. Possible

causes would be an insufficient number of mammographic apparatuses, lack of information, poor social status of this age category and lack of a program and measures for prevention and detection of breast cancer at the state level.

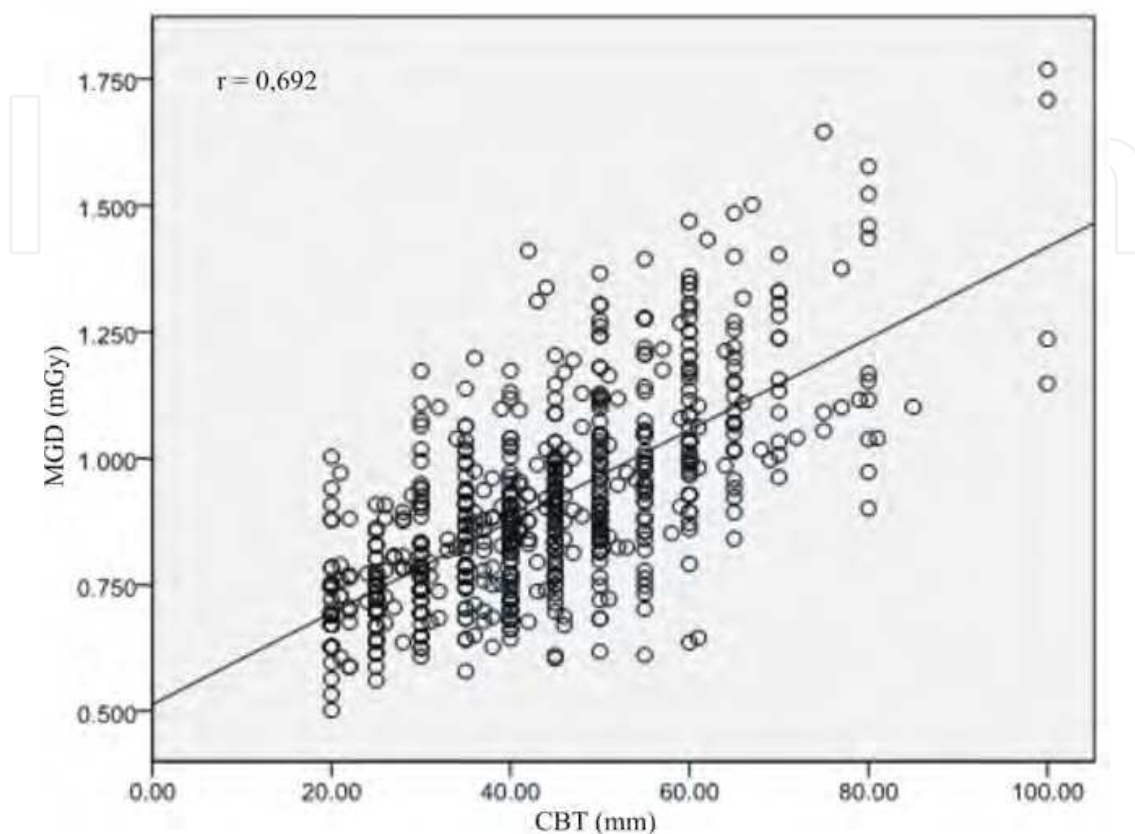


Fig. 3. Correlation between MGD and CBT for age group 50 – 64.

4. Conclusion

This work analyzes application of patient doses for various age groups of patients during a routine mammographic examination. One examined and analyzed factors on which patients doses depend. A correlation between patient doses and a complete spectrum of technical, physical, clinical and diagnostic parameters on which mammographic examination depends was established. The total dose for a complete mammographic examination was 3,58 mGy, which is significantly less than 4 mGy which is the ceiling for mammography. A slight tendency of compressed breast thickness increasing with age was noted for the age group 40 – 49. In the second age group, 50 – 64, it was noted that values of doses decreased with an increase of patients' age. It was defined that mean glandular dose depended on compressed breast thickness and that there was a positive correlation between these two sizes. More than 75 % of treated patients underwent at least 2 mammographic examinations in their lives. All patients underwent an ultrasound breast examination.

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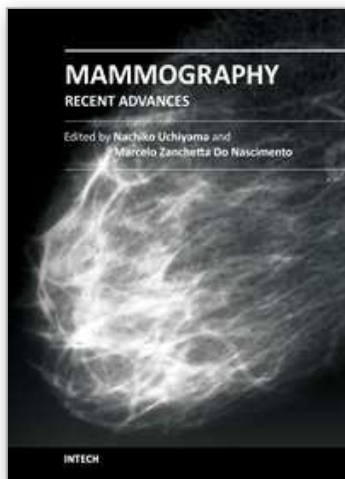
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In this volume, the topics are constructed from a variety of contents: the bases of mammography systems, optimization of screening mammography with reference to evidence-based research, new technologies of image acquisition and its surrounding systems, and case reports with reference to up-to-date multimodality images of breast cancer. Mammography has been lagged in the transition to digital imaging systems because of the necessity of high resolution for diagnosis. However, in the past ten years, technical improvement has resolved the difficulties and boosted new diagnostic systems. We hope that the reader will learn the essentials of mammography and will be forward-looking for the new technologies. We want to express our sincere gratitude and appreciation to all the co-authors who have contributed their work to this volume.

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51000 Rijeka, Croatia
Phone: +385 (51) 770 447
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Unit 405, Office Block, Hotel Equatorial Shanghai
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中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

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